whom he met in the Monbuttu country, and now Dr. Ludwig Wolf, who, with Wissmann, recently explored the Sankuru, the great southern tributary of the Congo, gives us many details of a similar pygmy race among whom he sojourned for some time, in the district to the north-west of the station Luluaburg. He found entire villages inhabited by tiny men and women, of a height of not more than 1·40 metre. Among their neighbours they are known as Batua. These are nomad tribes devoting themselves exclusively to the chase and the manufacture of palm wine. Their villages, consisting of huts, are met with in clearings in the forests which cover the greater part of the country. Each district thus possesses a village of pygmies. As is the case of the Akkas among the Monbuttus, so the Batua among the Bakubu are regarded as little benevolent beings whose special mission is to provide the tribes among whom they sojourn with game and palm-wine. In exchange, manioc, maize, and bananas are given to the pygmies. Generally they live apart, but sometimes they unite themselves with races of larger stature. They excel in the art of scaling palm-trees to collect the sap, and in setting traps for game. Their agility is almost incredible. In hunting they bound through the high grass like grasshoppers, facing the elephant, antelope, and buffalo with the greatest audacity, shooting their arrows with rare precision, following up rapidly with a stroke of the lance. Physically the Batua are very well made, having absolutely no deformity. They are simply little men, well proportioned, very brave, and very cunning. Their mean height is 1·30 metre. Their skin is a yellow-brown, less dark than that of larger races. Their hair is short and woolly. Neither the Akkas nor the Batua have any beard.

SUNLIGHT COLOURS[1]

SUNLIGHT is so intimately woven up with our physical enjoyment of life that it is perhaps not the most uninteresting subject that can be chosen for what is—perhaps somewhat pedantically—termed a Friday evening "discourse." Now, no discourse ought to be possible without a text on which to hang one's words, and I think I found a suitable one when walking with an artist friend from South Kensington Museum the other day. The sun appeared like a red disk through one of those fogs which the east wind had brought, and I happened to point it out to him. He looked, and said, "Why is it that the sun appears so red?" Being near the railway station, whither he was bound, I had no time to enter into the subject, but said if he would come to the Royal Institution this evening I would endeavour to explain the matter. I am going to redeem that promise, and to devote at all events a portion of the time allotted to me in answering the question why the sun appears red in a fog. I must first of all appeal to what everyone who frequents this theatre is so accustomed, viz. the spectrum; I am going not to put it in the large and splendid stripe of the most gorgeous colours before you with which you are so well acquainted, but my spectrum will take a more modest form of purer colours some twelve inches in length.

I would ask you to notice which colour is most luminous. I think that no one will dispute that in the yellow we have the most intense luminosity, and that it fades gradually in the red on the one side and in the violet on the other. This then may be called a qualitative estimate of relative brightnesses; but I wish now to introduce to you what was novel last year, a quantitative method of measuring the brightness of any part.

Before doing this I must show you the diagram of the apparatus which I shall employ in some of my experiments.

RR are rays (Fig. 1) coming from the arc light, or, if we were using sunlight, from a heliostat, and a solar image is formed by a lens, L_1, on the slit S_1 of the collimator C. The parallel rays produced by the lens L_2 are partially refracted and partially reflected. The former pass through the prisms P_1P_2, and are focused to form a spectrum by a lens, L_3, on D, a movable ground glass screen. The rays are collected by a lens, L_4, tilted at an angle as shown, to form a white image of the near surface of the second prism on F.

Passing a card with a narrow slit, S_2, cut in it in front of the spectrum, any colour which I may require can be isolated. The consequence is that, instead of the white patch upon the screen, I have a coloured patch, the colour of which I can alter to any hue lying between the red and the violet. Thus, then, we are able to get a real patch of very approximately homogeneous light to work with, and it is with these patches of colour that I shall have to deal. Is there any way of measuring the brightness of these patches? was a question asked by General Festing and myself. After trying various plans, we hit upon the method I shall now show you, and if anyone works with it he must become fascinated with it on account of its almost childish simplicity—a simplicity, I may remark, which it took us some months to find out. Placing a rod before the screen, it casts a black shadow surrounded with a coloured background. Now I may cast another shadow from a candle or an incandescence lamp, and the two shadows are illuminated, one by the light of the coloured patch and the other by the light from an incandescence lamp which I am using to-night. [Shown.] Now one stripe is evidently too dark. By an arrangement which I have of altering the resistance interposed between the battery and the lamp, I can diminish or increase the light from the lamp, first making the shadow it illuminates too light and then too dark compared with the other shadow which is illuminated by the coloured light. Evidently there is some position in which the shadows are equally luminous. When that point is reached, I can read off the current which is passing through the lamp, and having previously standardised it for each increment of current, I know what amount of light is given out. This value of the incandescence lamp I can use as an ordinate to a curve, the scale number which marks the position of the colour in the spectrum being the abscissa. This can be done for each part of the spectrum, and so a complete curve can be constructed which we call the illumination curve of the spectrum of the light under consideration.

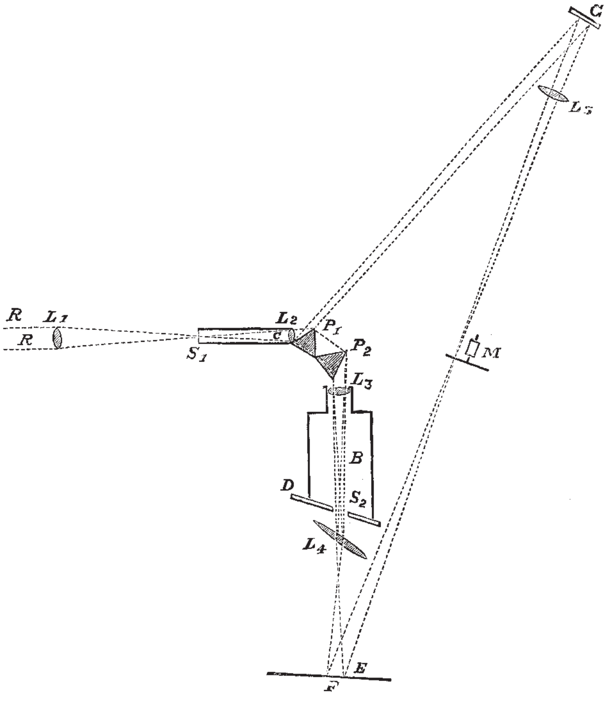

FIG. 1.—Colour Photometer.

Now, when we are working in the laboratory with a steady light, we may be at ease with this method, but when we come to working with light such as the sun, in which there may be constant variation owing to passing, and maybe usually imperceptible, mist, we are met with a difficulty; and in order to avoid this, General Festing and myself substituted another method, which I will now show you. We made the comparison light part of the light we were measuring. Light which enters the collimating lens partly passes through the prisms and is partly reflected from the first surface of the prism; that we utilise, thus giving a second shadow. The reflected rays from P_1 fall on G, a silver-on-glass mirror. They are collected by L_5, and form a white image of the prism also at F. The method we can adopt of altering the intensity of the comparison light is by means of rotating sectors, which can be opened or closed at will, and the two shadows thus made equally luminous. [Shown.] But although this is an excellent plan for some purposes, we have found it better to adopt a different method. You will recollect that the brightest part of the spectrum is in the yellow, and that it falls off in brightness on each side, so, instead of opening and closing the sectors, they are set at fixed intervals, and the slit is moved in front of the spectrum, just making the shadow cast by the reflected beam too dark or too light, and oscillating between the two till equality is discovered. The scale number is then noted, and the curve constructed as before. It must be remembered that, on each side of the yellow, equality can be established.

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[1] Lecture delivered by Capt. W. de W. Abney, R.E., F.R.S., at the Royal Institution, on February 25, 1887.

This method of securing a comparison light is very much better for sun work than any other, as any variation in the light whose spectrum is to be measured affects the comparison light in the same degree. Thus, suppose I interpose an artificial cloud before the slit of the spectroscope, having adjusted the two shadows, it will be seen that the passage of steam in front of the slit does not alter the relative intensities; but this result must be received with caution. [The lecturer then proceeded to point out the contrast colours that the shadow of the rod illuminated by white light assumed.]

I must now make a digression. It must not be assumed that everyone has the same sense of colour, otherwise there would be no colour-blindness. Part of the researches of General Festing and myself have been on the subject of colour-blindness, and these I must briefly refer to. We test all who come by making them match the luminosity of colours with white light, as I have now shown you; and as a colour-blind person has only two fundamental colour-perceptions instead of three, his matching of luminosities is even more accurate than is that made by those whose eyes are normal or nearly normal. It is curious to note how many people are more or less deficient in colour-perception. Some have remarked that it is impossible that they were colour-blind, and would not believe it, and sometimes we have been staggered at first with the remarkable manner in which they recognised colour to which they ultimately proved deficient in perception. For instance, one gentleman when I asked him the name of a red colour patch, said it was sunset colour; he then named green and blue correctly, but when I reverted to the red patch he said green. On testing further he proved totally deficient in the colour-perception of red, and with a brilliant red patch he matched almost a black shadow. The diagram shows you the relative perceptions in the spectrum of this gentleman and myself. There are others who only see three-quarters, others half, and others a quarter the amount of red that we see, whilst some see none. Others see less green and others less violet, but I have met with no-one that can see more than myself or General Festing, whose colour-perceptions are almost identical. Hence we have called our curve of illumination the "normal curve."

We have tested several eminent artists in this manner, and about one-half of the number have been proved to see only three-quarters of the amount of red which we see. It might be thought that this would vitiate their powers of matching colour, but it is not so. They paint what they see, and although they see less red in a subject, they see the same deficiency in their pigments; hence they are correct. If totally deficient, the case of course would be different.

Let us carry our experiments a step further, and see what effect what is known as a turbid medium has upon the illuminating value of different parts of the spectrum. I have here water which has been rendered turbid in a very simple manner. In it has been very cautiously dropped an alcoholic solution of mastic. Now mastic is practically insoluble in water, and directly the alcoholic solution comes in contact with the water it separates out in very fine particles, which, from their very fineness, remain suspended in the water. I propose now to make an experiment with this turbid water.

I place a glass cell containing water in front of the slit, and on the screen I throw a patch of blue light. I now change it for turbid water in a cell. This thickness much dims the blue; with a still greater thickness the blue has almost gone. If I measure the intensity of the light at each operation, I shall find that it diminishes according to a certain law, which is of the same nature as the law of absorption. For instance, if one inch diminishes the light one-half, the next will diminish it half of that again, the next half of that again, whilst the fourth inch will cause a final diminution of the total light of one-sixteenth. If the first inch allows only one-quarter of the light, the next will only allow one-sixteenth, and the fourth inch will only permit 1/256 part to pass. Let us, however, take a red patch of light and examine it in the same way. We shall find that, when the greater thickness of the turbid medium we used when examining the blue patch of light is placed in front of the slit, much more of this light is allowed to pass than of the blue. If we measure the light we shall find that the same law holds good as before, but that the proportion which passes is invariably greater with the red than the blue. The question then presents itself: Is there any connection between the amounts of the red and the blue which pass? Lord Rayleigh, some years ago, made a theoretical investigation of the subject; but, as far as I am aware, no definite experimental proof of the truth of the theory was made till it was tested last year by General Festing and myself. His law was that for any ray, and through the same thickness, the light transmitted varied inversely as the fourth power of the wave-length. The wave-length 6000 lies in the red, and the wave-length 4000 in the violet. Now 6000 is to 4000 as 3 to 2, and the fourth powers of these wave-lengths are as 81 to 16, or as about 5 to 1. If, then, the four inches of our turbid medium allowed three-quarters of this particular red ray to be transmitted, they would only allow $(\frac{3}{4})^5$, or rather less than one-fourth, of the blue ray to pass. Now this law is not like the law of absorption for ordinary absorbing media, such as coloured glass for instance, because here we have an increased loss of light running from the red to the blue, and it matters not how the medium is made turbid, whether by varnish, suspended sulphur, or what not. It holds in every case, so long as the particles which make the medium turbid are small enough; and please to recollect that it matters not in the least whether the medium which is rendered turbid is solid, liquid, or air. Sulphur is yellow in mass, and mastic varnish is nearly white, whilst tobacco-smoke when condensed is black, and very minute particles of water are colourless: it matters not what the colour is, the loss of light is *always* the same. The result is simply due to the scattering of light by fine particles, such particles being small in dimensions compared with a wave of light. Now, in this trough is suspended 1/1000 of a cubic inch of mastic varnish, and the water in it measures about 100 cubic inches, or is 100,000 times more in bulk than the varnish. Under a microscope of ordinary power it is impossible to distinguish any particles of varnish: it looks like a homogeneous fluid, though we know that mastic will not dissolve in water. Now a wave-length in the red is about 1/40,000 of an inch, and a little calculation will show that these particles are well within the necessary limits. Prof. Tyndall has delighted audiences here with an exposition of the effect of the scattering of light by small particles in the formation of artifical skies, and it would be superfluous for me to enter more into that. Suffice it to say that when particles are small enough to form the artificial blue sky they are fully small enough to obey the above law, and that even larger particles will suffice. We may sum up by saying that very fine particles scatter more blue light than red light, and that consequently more red light than blue light passes through a turbid medium, and that the rays obey the law prescribed by theory. I will exemplify this once more by using the whole spectrum and placing this cell, which contains hyposulphite of soda in solution in water, in front of the slit. By dropping in hydrochloric acid, the sulphur separates out in minute particles; and you will see that, as the particles increase in number, the violet, blue, green, and yellow disappear one by one and only red is left, and finally the red disappears itself.

Now let me revert to the question why the sun is red at sunset. Those who are lovers of landscape will have often seen on some bright summer's day that the most beautiful effects are those in which the distance is almost of a match to the sky. Distant hills, which when viewed close to are green or brown, when seen some five or ten miles away appear of a delicate and delicious, almost of a cobalt, blue colour. Now, what is the cause of this change in colour? It is simply that we have a sky formed between us and the distant ranges, the mere outline of which looms through it. The shadows are softened so as almost to leave no trace, and we have what artists call an atmospheric effect. If we go into another climate, such as Egypt or amongst the high Alps, we usually lose this effect. Distant mountains stand out crisp with black shadows, and the want of atmosphere is much felt. [Photographs showing these differences were shown.] Let us ask to what this is due. In such climates as England there is always a certain amount of moisture present in the atmosphere, and this moisture may be present as very minute particles of water—so minute indeed that they will not sink down in an atmosphere of normal density—or as vapour. When present as vapour the air is much more transparent, and it is a common expression to use, that when distant hills look "so close" rain may be expected shortly to follow, since the water is present in a state to precipitate in larger particles; but when present as small particles of water the hills look very distant, owing to what we may call the haze between us and them. In recent weeks everyone has been able to see very multiplied effects of such haze. The ends of long streets, for instance, have been scarcely visible though the sun may have been shining, and at night the long vistas of gas lamps have shown light having an increasing redness as they became more distant. Everyone admits the presence of mist on these occasions, and this mist must be merely a collection of intangible and very minute particles of suspended water. In a distant landscape we have simply the same or a smaller quantity of street-mist occupying, instead of perhaps 1000 yards, ten times that distance. Now I would ask, What effect would such a mist have upon the light of the sun which shone through it?

It is not in the bounds of present possibility to get outside our atmosphere and measure by the plan I have described to you the different illuminating values of the different rays, but this we can do:—First, we can measure these values at different altitudes of the sun, and this means measuring the effect on each ray after passing through different thicknesses of the atmosphere, either at different times of day, or at different times of the year, about the same hour. Second, by taking the instrument up to some such elevation as that to which Langley took his bolometer at Mount Whitney, and so to leave the densest part of the atmosphere below us. Now, I have adopted both these plans. For more than a year I have taken measurements of sunlight in my laboratory at South Kensington, and I have also taken the instrument up to 8000 feet high in the Alps, and made observations *there*, and with a result which is satisfactory in that both sets of observations show that the law which holds with artificially turbid media is under ordinary circumstances obeyed by sunlight in passing through our air: which is, you will remember, that more of the red is transmitted than of the violet, the amount of each depending on the wave-length. The luminosity of the spectrum observed at the Riffel I have used as my standard luminosity, and compared all others with it. The result for four days you see in the diagram.

I have diagrammatically shown the amount of different colours which penetrated on the same days, taking the Riffel as ten. It will be seen that on December 23 we have really very little violet and less than half the green, although we have four-fifths of the red.

The next diagram before you shows the minimum loss of light which I have observed for different air thicknesses. On the top we have the calculated intensities of the different rays outside our atmosphere. Thus we have that through one atmosphere, and two, three, and four; and you will see what enormous absorption there is in the blue end at four atmospheres. The areas of these curves, which give the total luminosity of the light, are 761, 662, 577, 503, and 439; and if observed as astronomers observe the absorption of light, by means of stellar observations, they would have had the values, 761, 664, 578, 504, and 439—a very close approximation one to the other.

Next notice in the diagram that the top of the curve gradually inclines to go to the red end of the spectrum as you get the light transmitted through more and more air, and I should like to show you that this is the case in a laboratory experiment. Taking a slide with a wide and long slot in it, a portion is occupied by a right-angled prism, one of the angles of 45° being towards the centre of the slot. By sliding this prism in front of the spectrum I can deflect outwards any portion of the spectrum I like, and by a mirror can reflect it through a second lens, forming a patch of light on the screen overlapping the patch of light formed by the undeflected rays. If the two patches be exactly equal, white light is formed. Now, by placing a rod as before in front of the patch, I have two coloured stripes in a white field, and though the background remains of the same intensity of white, the intensities of the two stripes can be altered by moving the right-angled prism through the spectrum. The two stripes are now apparently equally luminous, and I see the point of equality is where the edge of the right-angled prism is in the green. Placing a narrow cell filled with our turbid medium in front of the slit, I find that the equality is disturbed, and I have to allow more of the yellow to come into the patch formed by the blue end of the spectrum, and consequently less of it in the red end. I again establish equality. Placing a thicker cell in front, equality is again disturbed, and I have to have less yellow still in the red half, and more in the blue half. I now remove the cell, and the inequality of luminosity is still more glaring. This shows, then, that the rays of maximum luminosity must travel towards the red as the thickness of the turbid medium is increased.

The observations at 8000 feet, here recorded, were taken on September 15 at noon, and of course in latitude 46° the sun could not be overhead, but had to traverse what would be almost exactly equivalent to the atmosphere at sea-level. It is much nearer the calculated intensity for no atmosphere intervening, than it is for one atmosphere. The explanation of this is easy. The air is denser at sea-level than at 8000 feet up, and the lower stratum is more likely to hold small water particles or dust in suspension than is the higher.

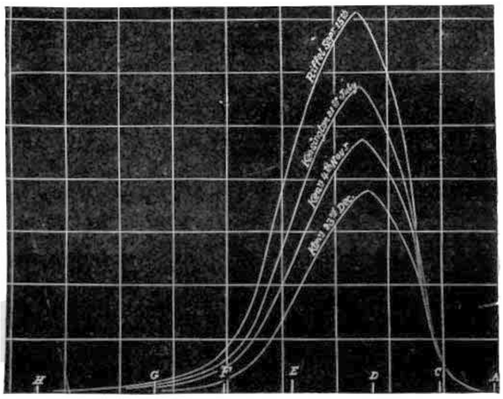

FIG. 2.—Relative Luminosities.

For, however small the particles may be, they will have a greater tendency to sink in a rare air than in a denser one, and less water vapour can be held per cubic foot. Looking, then, from my laboratory at South Kensington, we have to look through a proportionately larger quantity of suspended particles than we have at a high altitude when the air thicknesses are the same; and consequently the absorption is proportionately greater at sea-level that at 8000 feet high. This leads us to the fact that the real intensity of illumination of the different rays outside the atmosphere is greater than it is calculated from observations near sea-level. Prof. Langley, in this theatre, in a remarkable and interesting lecture, in which he described his journey up Mount Whitney to about 12,000 feet, told us that the sun was really blue

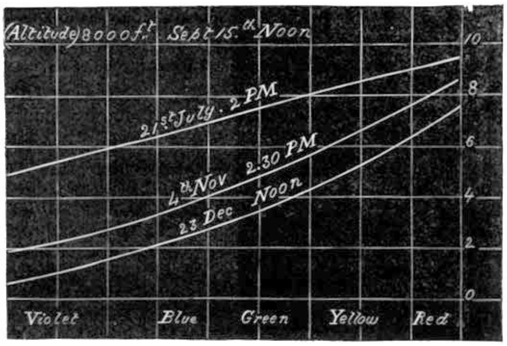

FIG. 3.—Proportions of Transmitted Colours.

outside our atmosphere, and at first blush the amount of extra blue which he deduced to be present in it would, he thought, make it so; but though he surmised the result from experiments made with rotating disks of coloured paper, he did not, I think, try the method of using pure colours, and consequently, I believe, slightly exaggerated the blueness which would result. I have taken Prof. Langley's calculations of the increase of intensity for the different rays, which I may say do not quite agree with mine, and I have prepared a mask which I can place in the spectrum giving the different proportions of each ray as calculated by him, and this when placed in front of the spectrum will show you that the real colour of sunlight outside the atmosphere, as calculated by Langley, can scarcely be called bluish. Alongside I place a patch of light which is very closely the colour of sunlight on a July day at noon in England. This comparison will enable you to gauge the blueness, and you will see that it is not very blue, and, in fact, not bluer perceptibly than that we have at the Riffel, the colour of the sunlight at which place I show in a similar way. I have also prepared some screens to show you the value of sunlight after passing through five and ten atmospheres. On an ordinary clear day you will see what a yellowness there is in the colour. It seems that after a certain amount of blue is present in white light the addition of more makes but little difference in the tint. But these last patches show that the light which passes through the atmosphere when it is feebly charged with particles does not induce the red of the sun as seen through a fog. It only requires more suspended particles in any thickness to induce it.

In observations made at the Riffel, and at 14,000 feet, I have found that it is possible to see far into the ultra-violet, and to distinguish and measure lines in the sun's spectrum which can ordinarily only be seen by the aid of a fluorescent eye-piece or by means of photography. Circumstantial evidence tends to show that the burning of the skin, which always takes place in these high altitudes in sunlight, is due to the great increase in the ultra-violet rays. It may be remarked that the same kind of burning is effected by the electric arc light, which is known to be very rich in these rays.

Again, to use a homely phrase, "You cannot eat your cake and have it." You cannot have a large quantity of blue rays present in your direct sunlight, and have a luminous blue sky. The latter must always be light scattered from the former. Now, in the high Alps you have, on a clear day, a deep blue-black sky, very different indeed from the blue sky of Italy or of England; and as it is the sky which is the chief agent in lighting up the shadows, not only in those regions do we have dark shadows on account of no intervening—what I will call—mist, but because the sky itself is so little luminous. In an artistic point of view this is important. The warmth of an English landscape in sunlight is due to the highest lights being yellowish, and to the shadows being bluish from the sky-light illuminating them. In the high Alps the high lights are colder, being bluer, and the shadows are dark, and chiefly illuminated by reflected direct sunlight. Those who have travelled abroad will know what the effect is. A painting in the Alps, at any high elevation, is rarely pleasing, although it may be true to Nature. It looks cold, and somewhat harsh and blue.

In London we are often favoured with easterly winds, and these, unpleasant in other ways, are also destructive of that portion of the sunlight which is the most chemically active on living organisms. The sunlight composition of a July day may, by the prevalence of an easterly wind, be reduced to that of a November day, as I have proved by actual measurement. In this case it is not the water particles which act as scatterers, but the carbon particles from the smoke.

Knowing, then, the cause of the change in the colour of sunlight, we can make an artificial sunset, in which we have an imitation light passing through increasing thicknesses of air largely charged with water particles. [The image of a circular diaphragm placed in front of the electric light was thrown on the screen in imitation of the sun, and a cell containing hyposulphite of soda placed in the beam. Hydrochloric acid was then added: as the fine particles of sulphur were formed, the disk of light assumed a yellow tint, and as the decomposition of the hyposulphite progressed, it assumed an orange and finally a deep red tint.] With this experiment I terminate my lecture, hoping that in some degree I have answered the question I propounded at the outset: why the sun is red when seen through a fog.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—From the University accounts for 1886, just issued, we learn that the Mathematical Tripos Examiners are paid 348*l.*; Examiners in Natural Science, 575*l.*; in Medicine and Surgery, 210*l.*; all extremely moderate payments.

Science Professors received 3725*l.* from the University Chest, 1800*l.* from the Common University Fund (derived from tax on the Colleges), besides payments from special endowments; Readers, Demonstrators, and other officers connected with Science and Medicine, 2100*l.* from the University Chest; 1800*l.* from the Common University Fund. Total, 9425*l.* for teachers mainly.

The University Observatory cost 786*l.*, in addition to 164*l.* from the Sheepshanks Fund. The Botanic Garden cost 1223*l.*; the Museums and Lecture Rooms, 4221*l.*, including 100*l.* for Dr. Guillemard's collection of bird-skins from the voyage of the *Marchesa*, 11*l.* for bird-skins bought by Prof. Newton at the Jardine sale, and 8*l.* 10*s.* for a skeleton of a European elk. The Pathological Laboratory cost 167*l.* out of the foregoing amount; the Department of Human Anatomy, 356*l.*; the Woodwardian Museum, 498*l.*; the Chemical Laboratory, 517*l.*; the Cavendish Laboratory, 274*l.*, including 60*l.* for instruments. The new dissecting-room (iron) for Human Anatomy cost 350*l.*, an additional class-room for Physiology 10*l.*, charged to the Museums Reserve Fund.

At Gonville and Caius College, Dr. Shuttleworth's Scholarship of 60*l.* for three years, open to medical students of the University of not less than eight terms' standing, given for proficiency in Botany and Comparative Anatomy, has been awarded to Francis Henry Edgeworth, B.A., Scholar of the College.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, March 3.—"On the Limiting Distance of Speech by Telephone." By William Henry Preece, F.R.S.

The law that determines the distance to which speaking by telephone on land-lines is possible, is just the same as that which determines the number of currents which can be transmitted through a submarine cable in a second.

It is dependent on a time-constant varying with the conditions of the circuit, invariable for the same uniform circuit, but differing for different circuits. It represents the time that elapses from the instant contact is made at the sending-end to the instant that the current begins to appear at the receiving-end. It is given by the following equation:—

$$a = \mathrm{B}krl^2,$$

B being a constant dependent principally on the units used; k the inductive capacity per unit length (mile or knot); r the resistance per unit length, and l the lengths in miles or knots.

The number of reversals which can be produced at the end of a wire per second is quite independent of the impressed E.M.F., and therefore of the strength of the current. But it depends upon the sensitiveness of the apparatus used to receive the currents. This is why such discordant results are obtained by different observers who attempt to measure the velocity of currents of electricity. It is also why the telephone is such an admirable instrument for research—for it is sensitive to the least increment or decrement of current.

The inductive capacity of overhead and underground wires was measured with great care on very dry days in different parts of the country.

The results come out as follows:—

	Capacity per mile, microfarads	Resistance per mile, B.A. ohms
No. 7½ iron wire	0·0168 ...	12·0
No. 12½ copper wire	0·0124 ...	5·7
Gutta-percha-covered wire in iron pipes	0·2500 ...	23·0
Gutta-percha-covered wire in cables	0·2900 ...	10·25

It then became necessary to determine the speed of the current through wires of different lengths, resistances, and capacities.

It was found that, for mixed wires, the speed was given by the equation

$$t = 32 \times 10^{-8}\ \mathrm{KR},$$

but for copper alone the constant was 22×10^{-8}.